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UNDERSTORY RESPONSE TO VARIED SPACING INTERVALS OF LODGEPOLE PINE (PINUS CONTORTA) IN WESTERN MONTANA

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Title: Understory Response to Varied Spacing Intervals of Lodgepole Pine (Pinus Contorta) in Western Montana[1]

Key Words: understory vegetation, spacing intervals, lodgepole pine

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ABSTRACT

Research on five forested sites in Montana and Idaho determined the response of understory vegetation to five spacing intervals of lodgepole pine (*Pinus contorta*). Understory yield generally decreased from wide to narrow spacings on four of the five sites. Grass species showed the greatest response to the varied spacing intervals, followed by forb and shrub species. Tree canopy cover was significantly correlated with understory yield on four of the five sites, but generally accounted for less than 60 percent of the variation in yield across the sites. Crude protein content of selected grass, forb, and shrub species did not differ significantly among the spacing intervals. The results indicate that thinning lodgepole pine stands to wide spacing intervals may result in a significant increase of understory vegetation compared with unthinned or lightly thinned stands. Percent tree canopy cover served as a fairly good predictor of understory vegetative yield.

INTRODUCTION

Natural regeneration of lodgepole pine (Pinus contorta) commonly results in overstocking and stagnation (Tackle 1959). Overly dense stands contribute little timber or understory vegetation. Most forest managers agree that if these stands are to make reasonable progress toward producing merchantable products they must be thinned.

While increased wood production on merchantable sized trees is the primary objective of thinning, this silvicultural practice may also exert an influence on understory forage supply for livestock and wildlife. Trappe and Harris (1958), in northeastern Oregon, reported 280 kg/ha of understory vegetation produced under open stands of lodgepole pine compared with 56 kg/ha under dense stagnated stands. Basile and Jensen (1971) observed in western Montana that understory vegetation reached peak production of 890 to 1120 kg/ha approximately 11 years after clearcutting of lodgepole pine. In central Oregon, Dealy (1975) reported that after nine years, thinned stands of lodgepole pine produced between 300 and 1000 percent more understory cover than before thinning.

To further substantiate the effects of lodgepole pine overstory on understory vegetation, I investigated the response of understory vegetative yield and crude protein content to five spacing intervals of lodgepole pine at five sites in Montana and Idaho.

Study Area and Methods

In 1964 the USDA Intermountain Forest and Range Experiment Station at Bozeman, Montana, initiated a study

to evaluate effects of spacing on the growth of lodgepole pine. This spacing experiment was replicated at six sites; four in Montana and one each in Idaho and Utah. In 1981 I examined the Montana and Idaho plots to determine the response of understory vegetation to varied spacing intervals of lodgepole pine. The Montana sites were on the Lewis and Clark, Bitterroot, Kootenai and Gallatin National Forests, while the Idaho site was on the Targhee National Forest (Figure 1).

The five study sites varied in latitude, elevation, topography, soils, and forest habitat types (Table 1). The habitat types were similar in that lodgepole pine is a major seral species in each, except for the *Thuja plicata*/*Clintonia uniflora* habitat type (Kootenai site) where it is a minor seral species (Pfister et al. 1977).

Each study site included a randomized complete block experimental design of two replications of five treatments. Treatments consisted of thinning lodgepole pine to five spacing intervals: 1.8 by 1.8 m (260 trees per treatment plot), 2.7 by 2.7 m (176 trees per treatment plot), 3.6 by 3.6 m (114 trees per treatment plot), 4.5 by 4.5 m (98 trees per treatment plot), and 5.4 by 5.4 m (98 trees per treatment plot). Treatment plot dimensions from the narrowest to the widest spacing level were: 18 by 48 m, 22 by 60 m, 22 by 68 m, 32 by 64 m, and 38 by 77 m, respectively. Each experimental area covered 1.7 hectares.

To determine herbaceous and shrub species yield, 25 concentric circular quadrats of 0.45 and 0.90 m^2 were sampled on each treatment plot. Each site was sampled at approximately the time of peak standing crop. Quadrats were located systematically from a randomly selected starting point. Individual species yields from four harvested and 21 estimated quadrats were combined in

Figure I. Location of study sites.

Figure 2. Understory vegetative yield among tree spacing intervals of five sites. Yield values not followed by the same letter are significantly different at the .05 level.

Figure 3. The relationship of tree canopy cover with understory vegetative yield of five sites.

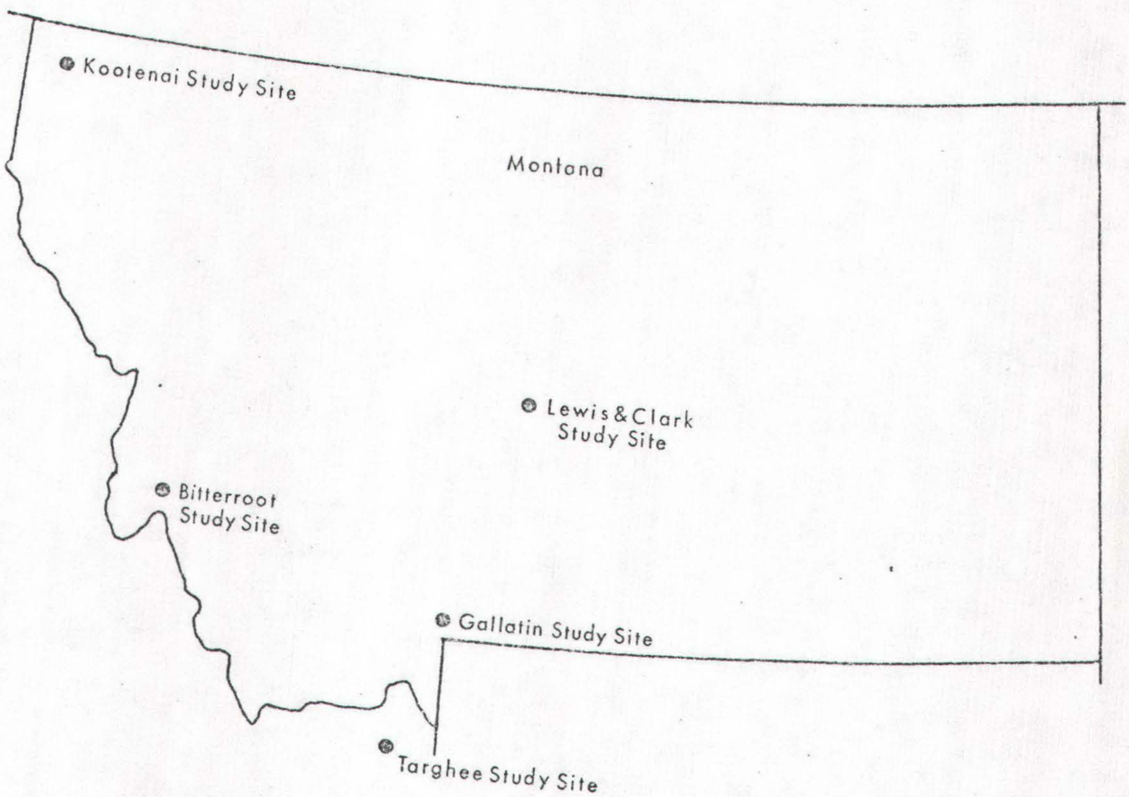

Kootenai Study Site
Montana
Lewis&Clark
Study Site
Bitterroot
Study Site
Gallatin Study Site
Targhee Study Site

Figure 2

Table 1. Physical Characteristics of the Study Sites.

SITES	Township Range Section	Elevation (m)	Slope %	Aspect	Soils	Habitat Type[1]	Site Index	Mean Annual Temp (°C)	Mean Annual Ppt (cm)
Targhee	13N43ES10	1951	2	East	cryopsamment	PSME/CARU	75	7	78
Kootenai	37N30WS19	973	level	–	cryochrept	THPL/CLUN	110	6	90
Lewis and Clark	11N10ES16	1946	3	Southeast	cryoboralf	ABLA/VASC	55	5	42
Gallatin	8S9ES35	2408	2	West	cryochrept, cryoboralf	ABLA/VASC	65	5	68
Bitterroot	3N18WS21	2088	6	Southwest	cryochrept, cryorthent	ABLA/XETE	85	5	40

[1] PSME/CARU = *Pseudotsuga menziesii/Calamagrostis rubescens* h.t.; THPL/CLUN = *Thuja plicata/Clintonia uniflora* h.t.; ALBA/VASC = *Abies lasiocarpa/Vaccinium scoparium* h.t.; ABLA/XETE = *Abies Lasiocarpa/Xerophyllum tenax* h.t. (Pfister et al. 1977).

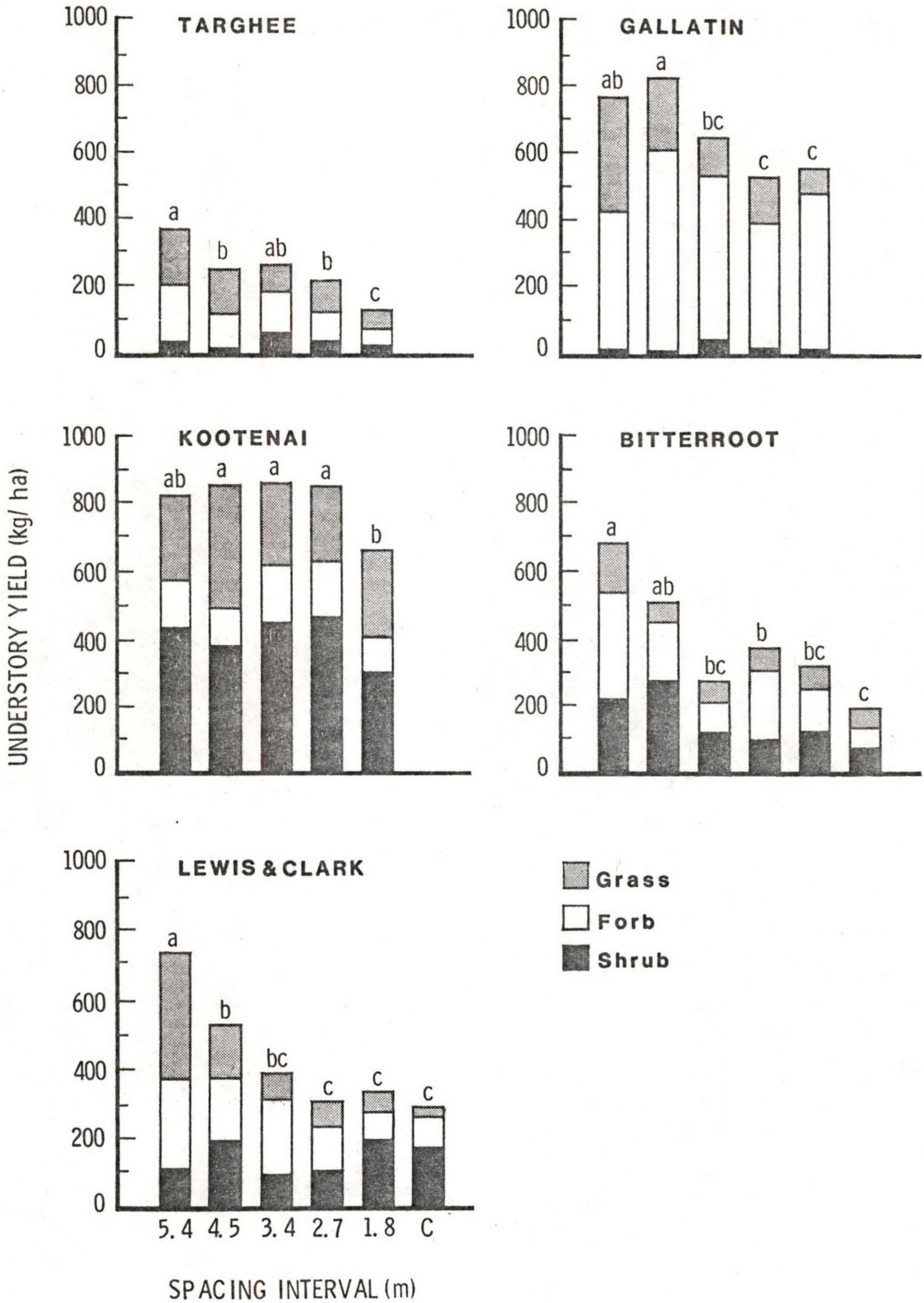
double sampling . Regression analysis was performed to adjust estimates from non-harvested quadrats. Vegetative samples were oven-dried at 60°C for 24 hours and weighed to the nearest 0.1g.

Crude protein analyses were performed on herbage and shrub samples collected August 2 from the Gallatin site and August 11 from the Bitterroot site. Three samples of a selected grass, forb, and shrub species along with a composite sample were collected from four treatment plots (1.8 by 1.8 m, 3.6 by 3.6 m, 5.4 by 5.4 m, and control). Composite samples were provided by harvesting three 0.45 m^2 quadrats.

Analysis of variance and Duncan's New Multiple Range Test (Duncan 1955) were used to determine if significant ($P<0.05$) differences of understory yield and crude protein content values existed among varied spacings. Linear regression and correlation analyses were used to determine the relationship between tree canopy cover (independent variable) and understory yield (dependent variable).

Results and Discussion

Understory yield tended to decrease from wide to narrow spacings on four of the five study sites (Figure 2). Understory yield on the Kootenai site did not differ among the varied tree spacings except for a significant decrease under the 1.8 m spacing. The lack of response by understory vegetation may be attributed to the age of the stand. The Kootenai stand was established in 1971 by planting lodgepole seedlings at designated spacings. In contrast, the other four sites were established in 1965-67 by thinning 10-12 year old lodgepole pine regeneration to designated spacings. On the Kootenai,



TARGHEE
GALLATIN
KOOTENAI
BITTERROOT
LEWIS & CLARK
UNDERSTORY YIELD (kg/ ha)
1000
800
600
400
200
0
a
b
ab
b
c
ab
a
bc
c
c
ab
a
a
a
b
a
ab
bc
b
bc
c
a
b
bc
c
c
c
Grass
Forb
Shrub
5.4
4.5
3.4
2.7
1.8
C
SPACING INTERVAL (m)

tree canopies had not yet thickened nor had root systems expanded sufficiently, at least under wide and intermediate spacings, to adversely affect understory vegetation. This is substantiated by statistically similar understory yield values reported for the varied tree spacings.

The responses of grasses, forbs, and shrubs to varied tree spacings differed among species and sites. All grass and grasslike species showed a similar tendency among the sites to decrease in yield from wide to narrow tree spacing. Pinegrass (Calamagrostis rubescens) and elk sedge (Carex geyeri) were the dominant grass and grasslike species across the range of study sites and although well represented under all spacing intervals, were most abundant under wider spacings.

Grasses also comprised a decreasing percentage of total understory vegetation with decreasing spacing. The decline of grasses may have been due to lowering of light intensity as overhead canopy thickened. Shading may reduce the relative growth rate of grasses thereby giving associated forbs and shrubs a competitive edge (Black 1957).

While most forb species generally decreased from wide to narrow tree spacings, lupine (Lupinus sericeus), heartleaf arnica (Arnica cordifolia), fireweed (Epilobium angustifolium) and showy aster (Aster conspicuus) either increased, first increased then decreased, or remained fairly constant. The influence of these four dominant understory species on total forb, as well as total understory, response to varied tree spacings was quite significant.

In contrast to grasses, forbs tended to comprise a larger percentage of total understory vegetation as tree spacing interval decreased. The dominance of forbs under semi-closed and closed tree canopies may be related to

leaf characteristics of size, shape, thickness, and orientation which allow for more efficient use of low light intensity (Donald and Black 1958).

Shrub species responded somewhat independently of tree spacing. Grouse whortleberry (Vaccinium scoparium) was the dominant shrub on all sites except for the Kootenai where bearberry (Arctostaphylos uva-ursi) dominated.

The correlation of tree canopy cover with understory yield revealed significant negative linear relationships among all sites except the Kootenai (Figure 3). Although overstory/understory relationships were significant, tree canopy cover accounted for only 42 percent of the variation in understory yield on the Bitterroot site, 49 percent on the Gallatin site, 55 percent on the Targhee site and 62 percent on the Lewis and Clark.

Tree canopy cover affected grass yield more than it did forb or shrub yields as indicated by the consistently higher coefficients of determination (Table 2). Of the four similar sites, the coefficients of determination of yield with tree canopy cover ranged from r^2=.66 to r^2=.28 for grasses, from r^2=.62 to r^2=.03 for forbs, and from r^2=.26 to r^2=.003 for shrubs.

Crude protein content of selected species from the Gallatin and the Bitterroot sites did not differ significantly among varied tree spacing intervals (Table 3). Composite samples, collected by clipping all species within three 0.45 m^2 quadrats, differed significantly between the 5.4 m and 1.8 m tree spacing on both sites. This difference may simply reflect the dominance of Lupinus sp. found on narrow tree spacings. An average protein value of 18 percent has been reported for lupine growing on similar forested sites (Hammond 1980).

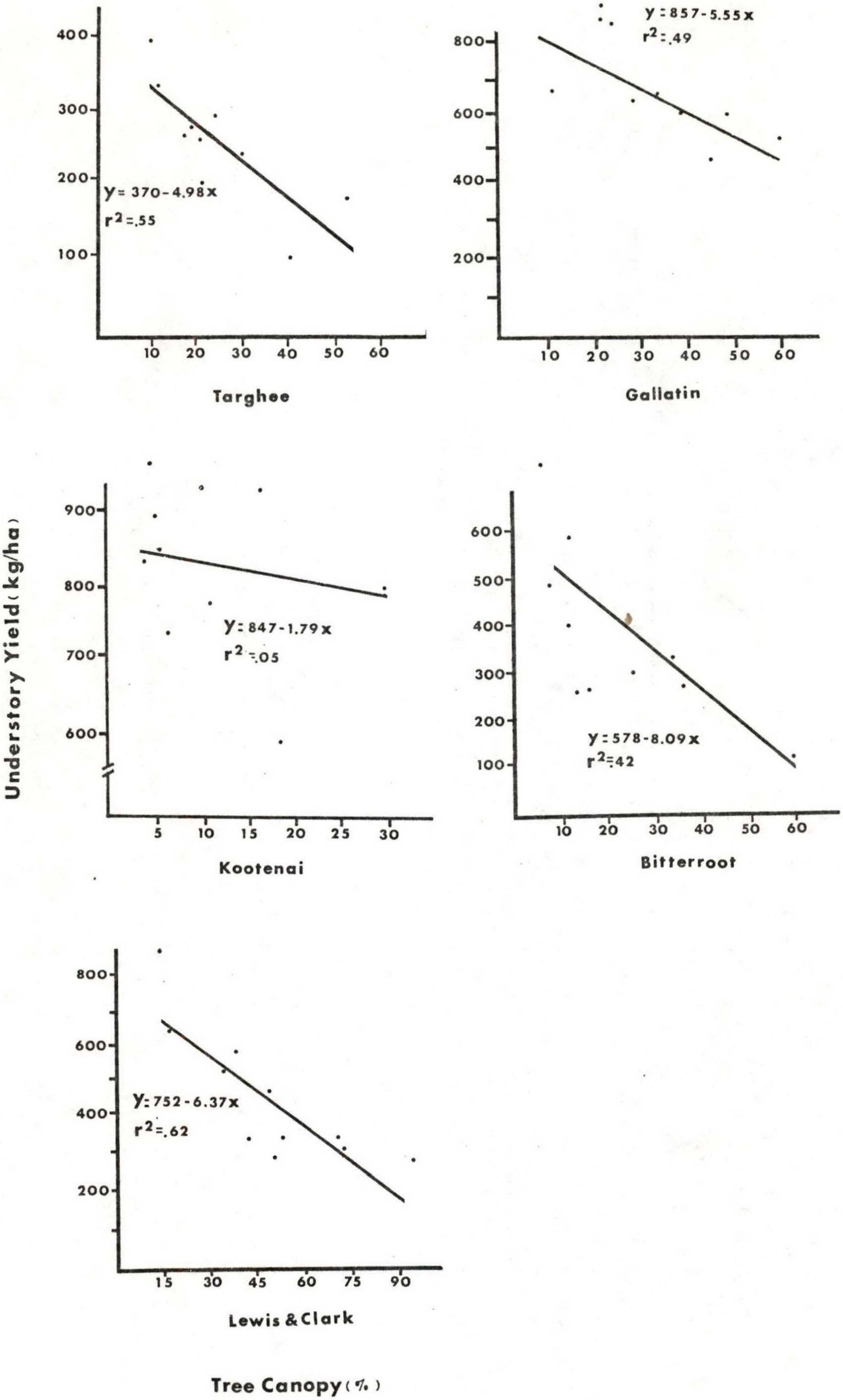

Understory Yield (kg/ha)
Targhee
y = 370-4.98x
r2 = .55
Gallatin
y = 857-5.55x
r2 = .49
Kootenai
y = 847-1.79x
r2 = .05
Bitterroot
y = 578-8.09x
r2 = .42
Lewis & Clark
y = 752-6.37x
r2 = .62
Tree Canopy (%)

Table 2. Simple correlation coefficients and coefficients of determination of tree canopy cover with understory vegetative yield.

Yield	Site									
	Targhee		Kootenai		Lewis-Clark		Gallatin		Bitterroot	
	r	r^2	r	r^2	r	r^2	r	r^2	r	r^2
Grass	-.76*	.58	-.I5	.02	-.8I*	.66	-.65*	.42	-.53	.28
Forb	-.70*	.49	-.05	.003	-.79*	.62	-.I8	.03	-.54	.29
Shrub	-.05	.003	-.35	.I2	+.23	.05	-.08	.006	-.5I	.26
Total	-.74*	.55	-.22	.05	-.79*	.62	-.70*	.49	-.65*	.42

* Correlation coefficient significant at the .05 level.

** Correlation coefficient significant at the .0I level.

Table 3 . Percent crude protein of selected species among the tree spacing intervals.

Sites	Tree Spacing Interval (m)			
	5.4	3.6	1.8	C
Gallatin Site				
Carex geyeri	6.2a[1]	5.8a	6.0a	-
Poa pratensis	5.0a	6.0a	5.0a	-
Epilobium angustifolium	13.8a	12.1a	12.5a	-
Composite	11.5a	13.5a	14.5b	-
Bitterroot Site				
Carex geyeri	5.3a	6.3a	7.6a	5.6a
Epilobium angustifolium	11.3a	12.6a	11.6a	13.0a
Vaccinium scoparium	7.2a	7.3a	6.8a	7.0a
Composite	10.3a	12.2ab	14.3b	13.6ab

[1]Means in rows not followed by the same letter are significantly different at the .05 level

Fireweed had a higher protein level than either bluegrass or elk sedge. This is to be expected as grasses experience a greater reduction in protein and phosphorus content over the growing season than do forbs (Cook and Harris 1950). Grouse whortleberry revealed protein values midway between grasses and forbs.

Summary and Conclusion

Basile and Jensen (1971) reported understory vegetation reached peak production of 890-1120 kg/ha approximately 11 years after clearcutting lodgepole pine. Results from the present study indicate similar production values may persist for approximately 30 years after clearcutting if immature stands are thinned to at least a 5.4 by 5.4 m spacing.

Thinning lodgepole pine to a 5.4 by 5.4 m spacing resulted in a significant increase of understory yield over stands which were unthinned or thinned to a 1.8 m spacing. Grass species generally comprised a larger percentage of total understory yield under wider tree spacings than under narrower spacings. Forbs generally comprised a larger percentage of total understory yield under narrower tree spacings than under wider spacings.

The correlation of tree canopy cover with total understory yield and grass yield generally revealed significant negative linear relationships on four of the five study sites. The correlation of tree canopy cover with forb and shrub yield generally revealed nonsignificant and more variable relationships.

The significant correlation of tree canopy cover and total understory vegetative yield may provide gross estimates of yield in advance of varied thinning inten-

sities. Quick estimates of understory vegetative yield based on tree canopy cover measurements may also be made.

Tree canopy cover had no influence on crude protein content of understory species. The crude protein content of selected grass, forb, and shrub species did not differ significantly among the varied tree spacings. Forb species contained the highest amount of protein followed by shrubs, then grasses.

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